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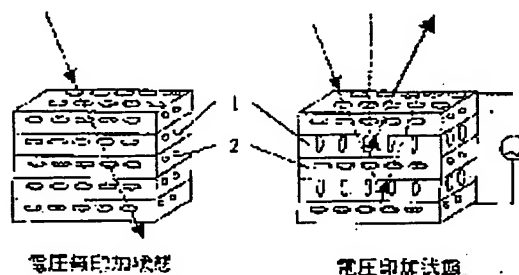
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(54) HOLOGRAM DISPLAY ELEMENT AND METHOD FOR MANUFACTURING THE SAME

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a hologram display element having enough reflectance and good optical anisotropy and to provide a method for manufacturing the display element.

SOLUTION: The hologram display element has a structural body produced by alternately laminating optical anisotropic liquid crystal layers and polymer layers held between a pair of substrates with transparent electrodes. In the method for manufacturing the hologram display element, a polymer precursor prepared from liquid crystal monoacrylates and polyfunctional acrylates having refractive index anisotropy is mixed with a specified amount of a non-polymerizable liquid crystal, then the mixture is injected into the gap between a pair of substrates with transparent electrodes and exposed to carry out photopolymerization to form the multilayered structure in which polymer layers produced by periodical polymerization of the polymer precursor and liquid crystal layers not polymerized are alternately laminated.



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CLAIMS

[Claim(s)]

[Claim 1] The hologram display device which pinched the structure which carried out the laminating of the liquid crystal layer and macromolecule layer of an optical anisotropy by turns between the substrates with a transparent electrode of a pair.

[Claim 2] A hologram display device including the multilayer structure which carried out the laminating of the macromolecule layer in which poured in the mixture of the photopolymerization nature macromolecule precursor and the optical anisotropy liquid crystal of non-polymerization nature which were mixed by the fixed ratio between the substrates with a transparent electrode of a pair, exposed it, and said macromolecule precursor carried out the polymerization periodically, and the liquid crystal layer of said non-polymerization nature by turns.

[Claim 3] The hologram display device according to claim 2 with which the macromolecule precursor is mixed by 20 - 50% of the weight of the ratio in the mixture of a macromolecule precursor and the liquid crystal of non-polymerization nature.

[Claim 4] The hologram display device according to claim 2 or 3 whose macromolecule precursor is the mixture of monoacrylate and polyfunctional acrylate.

[Claim 5] The hologram display device according to claim 2 to 4 whose monoacrylate which forms a macromolecule precursor is liquid crystallinity monoacrylate and whose polyfunctional acrylate is acrylate which includes in an end the unsaturated bond in which a polymerization is possible in the core section including a ring type functional group.

[Claim 6] The hologram display device according to claim 2 to 5 with which the polyfunctional acrylate which forms a macromolecule precursor is mixed by 10 - 50% of the weight of the ratio in the macromolecule precursor.

[Claim 7] The hologram display device according to claim 1 to 6 either [whose] the refractive index ne of the direction of a major axis or the refractive index no of the direction of a minor axis is liquid crystal almost equal to the refractive index of a macromolecule layer when a liquid crystal layer is 1 shaft optical anisotropy liquid crystal.

[Claim 8] The hologram display device according to claim 1 to 7 which adhered the orientation film to the field of the near transparent electrode with which said structure touches.

[Claim 9] The manufacture approach of the hologram display device which forms the multilayer structure in which the liquid crystal layer which has not carried out a polymerization to the macromolecule layer in which poured in the mixture of the macromolecule precursor formed from monoacrylate and polyfunctional acrylate and the liquid crystal of the non-polymerization nature of the specified quantity between the substrates with a transparent electrode of a pair, and performed photopolymerization by exposure, and the macromolecule precursor carried out the polymerization periodically carried out the laminating by turns.

[Claim 10] The manufacture approach of the hologram display device which forms the multilayer structure in which the liquid crystal layer which has not carried out a polymerization to the macromolecule layer in which performed photopolymerization by exposure and the macromolecule precursor carried out the polymerization periodically after having poured in the mixture of the macromolecule precursor formed from monoacrylate and polyfunctional acrylate and the liquid crystal of the non-polymerization nature of the specified quantity between the substrates with a transparent electrode of a pair, performing orientation processing and changing into a fixed

orientation condition carried out the laminating by turns.

[Claim 11] The manufacture approach of a display device according to claim 9 or 10 that the macromolecule precursor is mixed by 20 - 50% of the weight of the ratio in the liquid crystal of non-polymerization nature, and the mixture of a macromolecule precursor.

[Claim 12] The manufacture approach of a hologram display device according to claim 9 to 11 that a macromolecule precursor is the mixture of monoacrylate and polyfunctional acrylate.

[Claim 13] The manufacture approach of a hologram display device according to claim 9 to 12 that the monoacrylate which forms a macromolecule precursor is liquid crystallinity monoacrylate, and polyfunctional acrylate is acrylate which includes in an end the unsaturated bond in which a polymerization is possible in the core section including a ring type functional group.

[Claim 14] The manufacture approach of a hologram display device according to claim 9 to 13 that the polyfunctional acrylate which forms a macromolecule precursor is mixed by 10 - 50% of the weight of the ratio in the macromolecule precursor.

[Claim 15] The manufacture approach of a hologram display device according to claim 9 to 14 that interference exposure is laser light.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the liquid crystal display component used for displays, such as a display for information displays of information machines and equipment, such as a computer, and its manufacture approach.

[0002]

[Description of the Prior Art] The display of a liquid crystal display component is almost used for the information display in the information terminal [small /, such as a mobile computer,] which can be carried. The many use the liquid crystal of a super-twisted-nematic (STN) mold, and its use of a powerful back light is indispensable. In order to secure display capabilities also in a severe lighting environment for information terminals, such as the outdoors, it is necessary to make a back light still more powerful. For this reason, power consumption will increase, a dc-battery will be increased and the increase of weight of the whole information terminal equipment will be brought about as a result. Then, the reflection factor of a display device is improved greatly, the display device which realizes the good contrast property over an information display is called for, and the attempt used as a hologram component as one solution is performed.

[0003] By the way, the display device which one film used as the interference filter switchable in dispersion mode and fluoroscopy mode among the display devices which consist of multilayers which carried out the laminating of two or more film with which refractive indexes differ to JP,4-178624,A in order to raise the utilization factor and brightness of the reflected light is indicated. Moreover, the modulated light object which pinched the phase mold product hologram optical film which has the layer structure from which the component which the liquid crystal grain is distributing periodically is shown in the resin pinched between substrates, and distributed maintenance of the liquid crystal is carried out to JP,10-78569,A into a hardened material matrix at JP,4-355424,A, and a refractive index changes to it periodically in the interior as a hologram component between substrates with an electrode is shown.

[0004] However, these attempts have come to secure the optical anisotropy and the reflection factor sufficient as a hologram optical element which raise a KONSU trust property and enable a solid three-dimensions-display at coincidence.

[0005] Generally a refractive index uses for a hologram optical element the layer which changes periodically. That is, the specific wavelength which becomes settled with spacing (pitch) of a part with a high refractive index and a part with an adjoining high refractive index is penetrated alternatively, or is reflected alternatively. In such a display device, it is becoming a technical problem to enlarge optical anisotropy at the same time it raises the reflection factor of a component configuration as an information-display application although the refractive index of the film or a layer is adjustable therefore, and to make a contrast property good.

[0006] As an example of the technique which solves this technical problem, the attempt which enlarges the difference of a refractive index with a liquid crystal layer, using a liquid crystallinity macromolecule precursor as a macromolecule layer is shown in JP,10-78569,A. Moreover, the second layer of the optical anisotropy ingredient with which the first layer and direction of orientation of a controllable optical anisotropy ingredient do not depend for the direction of orientation on electric field by electric field at JP,10-123561,A is the structure by which the

laminating was carried out by turns. In the condition of not impressing electric field, what repeated periodically the layer which the direction of orientation of the first layer and the second layer is in agreement in general, answers electric field, and shows specific orientation, and the layer which does not answer electric field is indicated.

[0007] However, it does not become the display device which the fault that a macromolecule [not only liquid crystal but] side also answered this in case hologram structure is weak according to these attempts, and electric field are added and it drives arose, and the reflection factor was inadequate as a hologram display device, and was equipped with the contrast property good [of an information display] since optical anisotropy was small.

[0008]

[Problem(s) to be Solved by the Invention] A macromolecule precursor with which the refractive index of a liquid crystal layer and a macromolecule layer becomes larger is offered. Moreover, the manufacture approach of a hologram display device of having optical anisotropy is offered.

[0009] The hologram display device which has reflection factor with it by this is obtained. [large optical anisotropy and] [sufficient]

[0010]

[Means for Solving the Problem] The configuration of the display device which is the laminating structure in which the macromolecule layer and liquid crystal layer in configuration this invention of a display device carried out the laminating by turns is explained using the mimetic diagram of drawing 1 . In this invention, a hologram display device has the structure in which the liquid crystal layer 1 and the macromolecule layer 2 carried out the laminating by turns between the substrates with a transparent electrode of a pair. Since the polymerization of the macromolecule layer 2 is carried out in the state of uniform orientation, in the condition that the electric field from the outside are not impressed, its direction of orientation of the liquid crystal layer 1 and the macromolecule layer 2 corresponds in general. In this condition, the difference of the refractive index between the liquid crystal layer 1 and the macromolecule layer 2 is small enough to extent which is uninfluential to light transmission. For this reason, in electrical-potential-difference the condition of not impressing, as shown in the state diagram shown in the left of drawing 1 , the reflected light will not be produced to the incidence of light, but a display device will show a transparency condition. On the other hand, the electric field from the outside are impressed, in an electrical-potential-difference seal-of-approval condition, the liquid crystal layer 1 answers by the anisotropy of the refractive index, and, thereby, the difference of a refractive index arises between the liquid crystal layer 1 and the macromolecule layer 2. For this reason, as shown in the state diagram shown in the right of drawing 1 , the reflected light occurs to incident light, and a display device presents a reflective condition. The information display on a display is performed using this reflective condition and a transparency condition.

[0011] As a transparent electrode, what vapor-deposited ITO (Indium-Tin Oxide) to the glass substrate is used.

the outline of the manufacture approach of a display device -- the outline of the manufacture approach of the hologram display device which consists of the crosswise lamination structures of the macromolecule layer and liquid crystal layer in this invention next is described.

[0012] first, fixed in the macromolecule precursor of predetermined photopolymerization nature, and the liquid crystal of non-polymerization nature -- ratio mixing is carried out. A macromolecule precursor is mixed and prepared by monoacrylate, polyfunctional acrylate, and the fixed ratio. Next, a polymerization initiator is added by the fixed ratio to a macromolecule precursor. At this time, optimum dose addition of sensitizing dye or the polymerization retarder may be carried out if needed. Then, a macromolecule precursor and the liquid crystal of non-polymerization nature are mixed by the fixed ratio.

[0013] Next, this mixture is poured in between the substrates with a transparent electrode of a pair. Orientation processing of uniform orientation processing etc. is performed after that. In this case, the glass substrate which performed orientation processing beforehand may be used. Then, the photopolymerization reaction by exposure is performed to the mixture poured in between the substrates of a pair. An interference light etc. is used for exposure. By this photopolymerization reaction, the liquid crystal layer of the non-polymerization nature which does not carry out a

polymerization to the macromolecule layer in which the macromolecule precursor carried out the polymerization periodically carries out phase separation, a laminating is carried out by turns, multilayer structure is formed, and a hologram optical element is obtained. Moreover, the optical element obtained has large optical anisotropy, and a reflection factor will also become large.

[0014] Below, the manufacture approach of the hologram display device of this invention is stated to a detail.

Macromolecule precursor this invention persons found out that selection of the various high molecular compounds (henceforth a macromolecule precursor) which form a macromolecule layer was an important element, when a macromolecule layer and a liquid crystal layer produced the hologram display device which takes the multilayer structure which carried out the laminating by turns. That is, selection of the meso gene core which makes a refractive-index anisotropy discover in selection of a high molecular compound is an important element. For example, when using UV cure rubble liquid crystal as a high molecular compound of liquid crystallinity, it becomes possible as a meso gene core to form the macromolecule layer which has a high refractive-index anisotropy by using a biphenyl, triphenyl, a tolan frame, etc.

[0015] this invention persons examined wholeheartedly the liquid crystallinity high molecular compound suitable for production of the hologram display device which takes the multilayer structure in which the macromolecule layer and the liquid crystal layer carried out the laminating by turns from various liquid crystallinity high molecular compounds. Consequently, in order to produce a hologram display device, using what blended polyfunctional acrylate, such as diacrylate which has a high refractive-index anisotropy in the monoacrylate of the liquid crystallinity which shows a liquid crystal phase, at a predetermined rate, and was mixed at the thing which has a refractive-index anisotropy as a macromolecule precursor, especially photopolymerization initiation temperature found out that it was most suitable, and it resulted in completion of this invention.

[0016] As monoacrylate, liquid crystallinity monoacrylate without a methylene spacer is suitable between a liquid crystal frame and an acryloyloxy radical. When there was a methylene spacer and it macromolecule-izes, the liquid crystal responsibility over driver voltage gets worse, or a stabilization effect is not acquired. The liquid crystallinity monoacrylate which can be used for Table 1 by this invention is illustrated. Generally, these liquid crystallinity monoacrylate is called UV cure rubble liquid crystal, and is available at the Dainippon Ink trade names, such as UCL-001.

[0017]

[Table 1]

液晶性モノアクリレート

M1	$\text{CH}_2=\text{CHCOO}-\text{C}_6\text{H}_4-\text{C}_6\text{H}_4-\text{C}_2\text{H}_5$	M14	$\text{CH}_2=\text{CHCOO}-\text{C}_6\text{H}_4-\text{N}(\text{C}_6\text{H}_5)_2-\text{C}_6\text{H}_5$
M2	$\text{CH}_2=\text{CHCOO}-\text{C}_6\text{H}_4-\text{C}_6\text{H}_4-\text{C}_4\text{H}_9$	M15	$\text{CH}_2=\text{CHCOO}-\text{C}_6\text{H}_4-\text{N}(\text{C}_6\text{H}_5)_2-\text{C}_6\text{H}_5$
M3	$\text{CH}_2=\text{CHCOO}-\text{C}_6\text{H}_4-\text{C}_6\text{H}_4-\text{C}_7\text{H}_{15}$	M16	$\text{CH}_2=\text{CHCOO}-\text{C}_6\text{H}_4-\text{CH}_2\text{CH}_2-\text{C}_6\text{H}_4-\text{C}_2\text{H}_5$
M4	$\text{CH}_2=\text{CHCOO}-\text{C}_6\text{H}_4-\text{C}_6\text{H}_4-\text{C}_3\text{H}_7$	M17	$\text{CH}_2=\text{CHCOO}-\text{C}_6\text{H}_4-\text{C}\equiv\text{C}-\text{C}_6\text{H}_4-\text{C}_2\text{H}_5$
M5	$\text{CH}_2=\text{CHCOO}-\text{C}_6\text{H}_4-\text{C}_6\text{H}_4-\text{C}_4\text{H}_9$	M18	$\text{CH}_2=\text{CHCOO}-\text{C}_6\text{H}_4-\text{C}\equiv\text{C}-\text{C}_6\text{H}_4-\text{C}_4\text{H}_9$
M6	$\text{CH}_2=\text{CHCOO}-\text{C}_6\text{H}_4-\text{C}_6\text{H}_4-\text{OC}_8\text{H}_{17}$	M19	$\text{CH}_2=\text{CHCOO}-\text{C}_6\text{H}_4-\text{C}\equiv\text{C}-\text{C}_6\text{H}_4-\text{C}_8\text{H}_{17}$
M7	$\text{CH}_2=\text{CHCOO}-\text{C}_6\text{H}_4-\text{C}_6\text{H}_4-\text{C}_{10}\text{H}_{21}$	M20	$\text{CH}_2=\text{CHCOO}-\text{C}_6\text{H}_4-\text{C}_6\text{H}_4-\text{C}_2\text{H}_5$
M8	$\text{CH}_2=\text{CHCOO}-\text{C}_6\text{H}_4-\text{C}_6\text{H}_4-\text{COOC}_5\text{H}_{11}$	M21	$\text{CH}_2=\text{CHCOO}-\text{C}_6\text{H}_4-\text{C}_6\text{H}_4-\text{C}_4\text{H}_9$
M9	$\text{CH}_2=\text{CHCOO}-\text{C}_6\text{H}_4-\text{C}_6\text{H}_4-\text{COOC}_8\text{H}_{13}$	M22	$\text{CH}_2=\text{CHCOO}-\text{C}_6\text{H}_4-\text{C}_6\text{H}_4-\text{C}_6\text{H}_4-\text{F}$
M10	$\text{CH}_2=\text{CHCOO}-\text{C}_6\text{H}_4-\text{C}_6\text{H}_4-\text{COOC}_7\text{H}_{15}$	M23	$\text{CH}_2=\text{CHCOO}-\text{C}_6\text{H}_4-\text{C}_6\text{H}_4-\text{C}_6\text{H}_4-\text{F}$
M11	$\text{CH}_2=\text{CHCOO}-\text{C}_6\text{H}_4-\text{C}_6\text{H}_4-\text{COOC}_6\text{H}_{17}$	M24	$\text{CH}_2=\text{CHCOO}-\text{C}_6\text{H}_4-\text{N}(\text{C}_6\text{H}_5)_2-\text{C}_6\text{H}_4-\text{C}_8\text{H}_{17}$
M12	$\text{CH}_2=\text{CHCOO}-\text{C}_6\text{H}_4-\text{C}_6\text{H}_4-\text{COO}-\text{C}_6\text{H}_4-\text{C}_6\text{H}_5$	M25	$\text{CH}_2=\text{CHCOO}-\text{C}_6\text{H}_4-\text{C}\equiv\text{C}-\text{C}_6\text{H}_4-\text{C}_6\text{H}_4-\text{F}$
M13	$\text{CH}_2=\text{CHCOO}-\text{C}_6\text{H}_4-\text{C}_6\text{H}_4-\text{COO}-\text{C}_6\text{H}_4-\text{C}_6\text{H}_5$		

[0018] Moreover, the compound which includes the upright core section containing a ring type functional group and the chain-like end permuted by the functional group which has the unsaturated bond in which a polymerization is possible as polyfunctional acrylate, and the compound which has the frame of liquid crystal ingredient resemblance are used. A certain thing has [0.05 or more / 0.1 or more] the preferably desirable refractive-index difference which this polyfunctional acrylate has a refractive-index anisotropy, and reflects an anisotropy. As an example of the upright core section containing a ring type functional group, phenyl, a biphenyl, triphenyl, cyclohexyl phenyl, naphthyl, tolan, acetyl tolan, etc. can be mentioned.

[0019] Moreover, also in order to make management of a process easy, as for the monoacrylate and polyfunctional acrylate which are used by this invention, what shows liquid crystallinity near polymerization initiation temperature is desirable.

[0020] Each mixes and uses monoacrylate and polyfunctional acrylate to the whole macromolecule precursor by the ratio of 10 to 50% of the weight of the range preferably. Moreover, also in order to hold that of the display device configuration itself which is a layered product, mechanical fixed reinforcement is required for a macromolecule layer. That is, fixed integrity is required. For this reason, that whose glass transition point (Tg) of a macromolecule is 80 degrees C or more preferably beyond a room temperature is good. Just the liquid crystallinity monoacrylate of the mechanical strength of a macromolecule is inadequate, and suitable integrity can be given by using polyfunctional acrylate.

In non-polymerization nature liquid crystal this invention, non-polymerization nature liquid crystal has that desirable to which an orientation condition can be changed into by impression of the electric field from the outside, and a refractive index can be changed by the dielectric anisotropy. Although what is in a liquid crystal condition is advantageously used on management of a process in polymerization temperature, it is not restricted to this. For example, available liquid crystal can be used by the trade name of LICRILITE (trademark) by Merck Co. Among these, the description of the liquid crystal which can be used in this invention is illustrated and hung up over Table 2. Table 2

-- setting -- S-N (degree C) and N-I (degree C) -- in the phase transition temperature of liquid crystal, and deltaepsilon, a refractive-index anisotropy and no show the refractive index of the direction of a liquid crystal molecule minor axis, and, as for a dielectric constant anisotropy and epsilon||, K33 [K11, K33, and]/K11 show the elastic coefficient of a liquid crystal molecule, as for the dielectric constant of the direction of a liquid crystal molecule major axis, and deltan.

[0021]

[Table 2]

液晶の性状

Mixture:	TL202	TL203	TL204	TL205
S-N [°C]	+1	<-20	-6	<-20
N-I [°C]	+83	+77	+92	+87
Viscosity (cSt) 20°C	37	37	43	45
$\Delta\epsilon$ (1 kHz, 20°C)	+6.1	+11	+4.8	5.0
$\epsilon_{ }$ (1 kHz, 20°C)	9.6	15.2	8.9	9.1
$V_{(10,0,20)}$	2.73	1.92	2.88	2.75
$V_{(90,0,20)}$	3.70	2.62	3.83	3.79
Δn (589nm, 20°C)	0.1851	0.2013	0.207	0.217
n_e (589nm, 20°C)	1.5230	1.529	1.521	1.527
K_{11} +20°C	19.10	15.80	18.60	17.30
K_{33} +20°C	20.10	17.90	20.50	20.40
K_{33}/K_{11} +20°C	1.05	1.13	1.10	1.18
Mixture:	TL213	TL215	TL216	
S-N [°C]	<-20	<-20	<-20	
N-I [°C]	+87	+82	+80	
Viscosity (cSt) 20°C	49	44	36	
$\Delta\epsilon$ (1 kHz, 20°C)	+5.7	+8.5	+5.5	
$\epsilon_{ }$ (1 kHz, 20°C)	10.0	12.8	9.7	
Δn (589nm, 20°C)	1.527	1.520	1.523	
n_e (589nm, 20°C)	0.239	0.204	0.211	
K_{11} +20°C	16.8	14.1	14.4	
K_{33} +20°C	22.00	18.7	19.6	
K_{33}/K_{11} +20°C	1.30	1.33	1.36	

[0022] In order to enlarge the difference of the refractive index between a liquid crystal layer and a macromolecule layer, a thing with the largest possible refractive-index anisotropy is suitable. In order to realize the good contrast property in a display device furthermore, it is desirable for either to consider as an equal mostly with the refractive index of a macromolecule layer among the refractive indexes of n_e of the liquid crystal of non-polymerization nature or n_o . Generally, the liquid crystal molecules which have an optically uniaxial optical anisotropy differ in a refractive index in the direction of a molecule major axis, and the direction of a minor axis. When expressed with the index ellipsoid of the optical anisotropy liquid crystal of one shaft to drawing 2, n_e expresses the refractive index of the direction of a major axis of a liquid crystal molecule, and n_o expresses the refractive index of the direction of a minor axis of a liquid crystal molecule. Thus, by making the refractive index of the direction of a major axis of a liquid crystal molecule, or the direction of a minor axis mostly in agreement with the refractive index of a macromolecule layer, it can prevent gap arising from the exterior between the orientation of liquid crystal and the orientation of a macromolecule layer in the condition that there is no impression of electric field, optical anisotropy can be given to the reflection property of a hologram optical element, and a good contrast property can be acquired.

[0023] 30 to 40% of the weight of a ratio is suitable for the mixed ratio of non-polymerization nature liquid crystal to the mixture of non-polymerization nature liquid crystal and a macromolecule precursor. If it exceeds 40 % of the weight, the inclination which does not form a homogeneous layer

will be seen. Moreover, if fewer than 30 % of the weight, reflection factor sufficient as a hologram display device cannot be attained.

A polymerization initiator polymerization initiator is added if needed to the mixture of the macromolecule precursor and non-polymerization nature liquid crystal which are obtained. If it is the polymerization initiator which can generate a radical by the light source used for exposure as a polymerization initiator, what kind of thing can also be used. For example, it is commercially available under the name of the IRUGA cure (trademark) of Ciba-Geigy, and the polymerization initiator which can be used is used. It is used suitably if needed, changing an addition.

An addition can be changed and used for a polymerization retarder polymerization retarder if needed to the mixture of the macromolecule precursor and non-polymerization nature liquid crystal which are obtained. However, since a reaction rate is decided by combination of a polymerization initiator and a macromolecule precursor, also when a polymerization retarder does not necessarily need to be added, it is. PARAFE nil styrene etc. can be used as a polymerization retarder.

photosensitization coloring matter may be mixed if needed to the mixture of a photosensitization coloring matter profit **** macromolecule precursor and non-polymerization nature liquid crystal.

A thioxan ton system photopolymerization initiator may be used as photosensitization coloring matter. The thing of trade names, such as KAYACURE DETX-S, can be obtained and used for a thioxan ton system photopolymerization initiator from Nippon Kayaku.

In the display device of orientation processing (uniform orientation processing) this invention, also in the condition of not impressing the electric field from the outside, in order that a liquid crystal layer may consider as a fixed orientation condition, orientation processing is performed. Since the direction of orientation of a liquid crystallinity macromolecule precursor and a liquid crystal layer can be made in agreement in general in the condition that the electric field from the outside are not impressed, by this processing, the transparency condition of incident light can be made. This means that it can make the most of the difference of a refractive index with a reflective condition, and, as a result, can show a high reflection factor and a good contrast property to the information display on a display device.

[0024] Using the glass substrate which performed orientation processing beforehand, the orientation processing in this invention may perform orientation processing, after pouring in the mixture of a macromolecule precursor and liquid crystal between the substrates with an electrode of a pair. The approach by the orientation approach established by the technical field of a liquid crystal display component, for example, the rubbing method, the method vacuum deposition of slanting of SiO₂, the optical orientation approach and electric field, and the magnetic field etc. can be used for control of orientation processing. Furthermore, in order to acquire a high orientation condition, it is good also as a condition to which uniform orientation of electric field or the magnetic field was added and carried out. Moreover, the orientation film is adhered to a substrate and orientation processing can also be performed. Polyimide etc. is used for the orientation film in this case.

A photopolymerization reaction photopolymerization reaction is performed by exposing an interference light to the mixture of the macromolecule precursor and non-polymerization nature liquid crystal which were poured in between the substrates with an electrode of a pair. Laser light etc. can be used for the interference light for exposure. For example, laser light, such as 407nm krypton laser, is suitable. A photopolymerization reaction is performed by carrying out 2 flux-of-light interference exposure using 407nm krypton laser. Exposure reinforcement can be performed in the range of 10 - 300 mW/cm². Moreover, irradiation time can be performed in 0.5 minutes - 3 minutes.

[0025] In addition, in interference exposure, any hologram display device of the type of a reflective mold hologram optical element and a transparency mold (diffraction-grating mold) hologram optical element is producible by adjusting the optical path of 2 flux-of-light interference optical system. The mimetic diagram showed the exposure approach to drawing 3.

[0026] In order to make a desired hologram form by laser light, it is necessary to control the reaction rate of the macromolecule precursor of photopolymerization nature. That is, to the diffusion rate of a macromolecule precursor, when a reaction rate is too large, the radical generated with a macromolecule precursor and laser light cannot fully diffuse between the interference fringes produced by interference exposure. As this cure, a polymerization retarder may be added to a

macromolecule precursor and a reaction condition may be controlled. Through the example described below, if a polymerization retarder is added about 1% of the weight to a macromolecule precursor, that a good reaction condition is also realizable has found out this invention persons. Thus, formation of a hologram optical element with high diffraction efficiency becomes easy by control of a reaction rate.

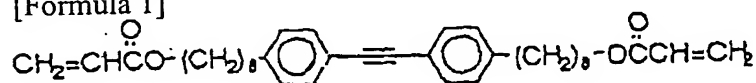
[0027] Since the liquid crystallinity macromolecule precursor used in this invention as polymerization temperature shows liquid crystal at a room temperature, a room temperature is adopted suitably. Although the management top of a process has an advantageous room temperature, it can be chosen from a room temperature as arbitration if needed in the range of the N-I transition point of liquid crystal / macromolecule precursor mixture.

[0028] UV light of fixed reinforcement is irradiated and an unreacted polymerization initiator, a macromolecule precursor, a polymerization retarder, sensitizing dye, etc. are made to react completely after the completion of a photopolymerization reaction.

[0029]

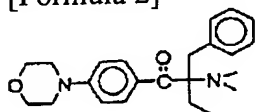
[Example] Sumitomo Chemical SA- which has a tolan frame as monoacrylate as Dainippon Ink 001 [UCL-] (it is equivalent to the mixture of M4 and M19 of Table 1), and polyfunctional acrylate in order to prepare an example 1 macromolecule precursor and which is diacrylate -- 2 [0030]

[Formula 1]



[0031] ***** The refractive-index anisotropy in this diacrylate simple substance was about 0.2. This diacrylate was mixed to the whole macromolecule precursor to 5 - 100% of the weight of the blending ratio of coal. Next, it is Ciba-Geigy Irgacure639 [0032] as a polymerization initiator to the prepared giant-molecule precursor.

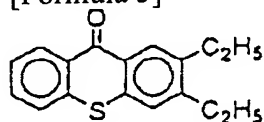
[Formula 2]



[0033] It added 1% of the weight, and PPST (PARAFE nil styrene) by Nippon Kayaku Co., Ltd. was added 1% of the weight as a polymerization retarder. It mixed so that it might become 30% of the weight into this macromolecule precursor mixture to the whole mixture about TL213 by Merck Co. as liquid crystal. About the description of TL213 by Merck Co., it is as in Table 2.

[0034] Subsequently, it is KAYACURE DETX-S [0035] by Nippon Kayaku Co., Ltd. as photosensitization coloring matter to this mixture.

[Formula 3]



[0036] It added 2% of the weight to the whole mixture. Next, the production approach of the cel for evaluation is described. The glass cell of 5 micrometers of cel thickness made from EHC was used for the cel. ITO is vapor-deposited as a transparent electrode and polyimide is applied as orientation film. Moreover, rubbing of the orientation processing is carried out antiparallel (the directions of rubbing are 180 relation with a vertical substrate). After injecting the mixture of said liquid crystal and macromolecule precursor into this cel, it exposed at the room temperature and photopolymerization was performed. High power [by the U.S. coherent company] water-cooled Kr ion laser (part number Sabre Kr) was used for exposure. By carrying out 2 flux-of-light interference exposure using 407nm krypton laser, the refractive index produced the component which has the structure which carried out the laminating by turns [of the liquid crystal layer and macromolecule layer which change periodically]. Exposure reinforcement was 160 mW/cm² and irradiation time was for 1 minute. The optical path was adjusted in interference exposure and the reflective mold hologram optical element was obtained.

[0037] After interference exposure, in order to make an unreacted polymerization initiator, a macromolecule precursor, a polymerization retarder, and sensitizing dye react completely, UV light of 365nm and 20 mW/cm² was irradiated for 30 seconds.

[0038] The reflectance spectrum of the produced optical element was measured with the microspectrophotometer. The spectral reflectance estimated the reflection factor and it made the dielectric mirror 100% as a reference. An example of the obtained spectrum is shown in drawing 4.

[0039] A measurement result is shown in Table 3. When the addition of diacrylate was 50 % of the weight from 10 % of the weight to the whole macromolecule precursor, the reflection factor exceeded 20%. This shows that the difference of the refractive index of a liquid crystal layer and a macromolecule layer was able to be effectively taken out in the produced display device by mixing of diacrylate which has a refractive-index anisotropy. That is, the hologram optical element with high diffraction efficiency was able to be obtained. In addition, the display device which mixed diacrylate and was obtained has checked that it was a hologram optical element in all mixing ratios.

[0040]

[Table 3]

ジアクリレートの混合比と反射率

ジアクリレートの混合比 (重量%)	0 %	10%	20%	30%	40%	50%	60%
反射率 (567nm)	20%	25%	25%	30%	36%	35%	20%

[0041] Using the liquid crystal and giant-molecule precursor mixture (the mixing ratio of diacrylate is 40 % of the weight) which were used in the example 2 example 1, the mixing ratio of the giant-molecule precursor in the mixture of non-polymerization nature liquid crystal and a giant-molecule precursor was gradually changed from 20 % of the weight to 50% of the weight, and was poured in into the same evaluation cel as an example 1 about each mixture, and the reflective mold hologram optical element was produced by carrying out 2 flux-of-light interference exposure. The reflectance spectrum of the obtained hologram optical element was measured with the microspectrophotometer. The spectral reflectance estimated the reflection factor and it made the dielectric mirror of a reference 100%.

[0042] A measurement result is shown in Table 4. In 20 to 50% of the weight of the range, 20% or more of high reflection factor was able to be obtained for the mixing ratio of the macromolecule precursor in the mixture of non-polymerization nature liquid crystal and a macromolecule precursor. Moreover, the hologram optical element which a reflection factor exceeds 25% by adjusting the mixing ratio of the macromolecule precursor in the mixture of non-polymerization nature liquid crystal and a macromolecule precursor to 40% of the weight from 30 % of the weight, and has a good optical anisotropy was producible.

[0043]

[Table 4]

高分子前駆体／液晶の混合比と反射率

高分子前駆体の混合比 (重量%)	15%	20%	30%	40%	50%	60%
反射率(567nm)	20%	25%	36%	27%	20%	15%
光学異方性	○	○	○	○	△	△

[0044] Except not mixing the polyfunctional acrylate which has an example of comparison 1 refractive-index anisotropy, it is the same conditions (0% of mixing ratios of Table 3) as the mixture of the liquid crystal / macromolecule precursor used in the example 1, and the reflective mold hologram optical element was produced. Moreover, the reflection factor was 20% as a result of measuring the reflectance spectrum of the produced optical element with a microspectrophotometer. Optical anisotropy was inadequate.

Using the mixture of the liquid crystal used in the example of comparison 2 example 2, and a macromolecule precursor, the rate of a macromolecule precursor was adjusted to 20 or less % of the weight and 50% of the weight or more, it poured in into the evaluation cel same about each mixture as an example 1, and the reflective mold optical element was produced. The reflectance spectrum of

the obtained optical element was measured with the microspectrophotometer.

[0045] An optical anisotropy was not able to be held, although the orientation condition of the mixture of a macromolecule precursor and liquid crystal was confused by the concentration by which its reflection factor is as low as 20% or less with concentration, and it exceeds 50 % of the weight although 20 or less % of the weight of a thing forms a hologram optical element and the concentration of a macromolecule precursor formed the hologram optical element.

[0046]

[Effect of the Invention] This invention was able to obtain the hologram optical element which the reflection factor of a display device is raised and has big optical anisotropy by considering as the component for liquid crystal displays which consists of multilayer-structure objects which carried out the laminating of the liquid crystal layer and macromolecule layer of the optical anisotropy whose refractive index is adjustable. Moreover, using mixture with the polyfunctional acrylate which has the monoacrylate and the refractive-index anisotropy of liquid crystallinity at the macromolecule precursor which forms a macromolecule layer, using mixture with the liquid crystal of non-polymerization nature mixed with said macromolecule precursor by the fixed ratio, the hologram optical element of the laminating structure of a liquid crystal layer / macromolecule layer was able to be obtained, and the reflection factor was able to obtain the large and, large hologram optical element of optical anisotropy by the photopolymerization reaction by interference exposure. The display device which shows the high reflection factor to an information display and a good contrast property by this was able to be obtained. Moreover, in order that crosslinking reaction might occur within a macromolecule layer in the case of photopolymerization, the upright macromolecule layer was able to be obtained.

[Translation done.]

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1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the mimetic diagram of a display device configuration.

[Drawing 2] It is the mimetic diagram of the refractive index of a liquid crystal molecule.

[Drawing 3] It is the mimetic diagram showing the interference exposure approach.

[Drawing 4] micro -- it is the reflectance spectrum measured with the spectrum.

[Description of Notations]

1: Liquid crystal layer

2: Macromolecule layer

[Translation done.]

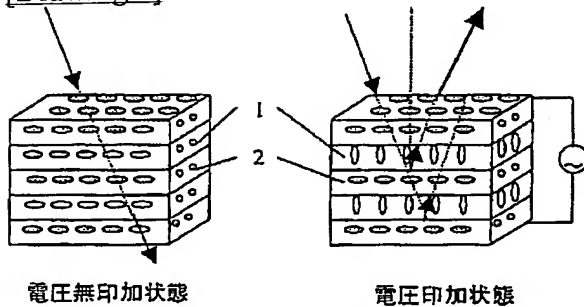
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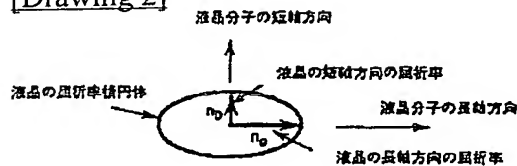
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DRAWINGS

[Drawing 1]



[Drawing 2]



[Drawing 3]

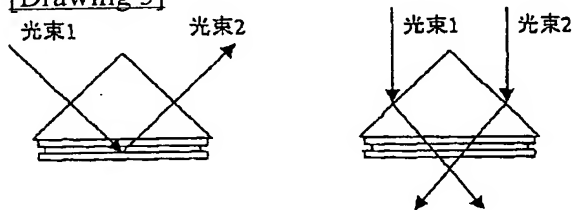
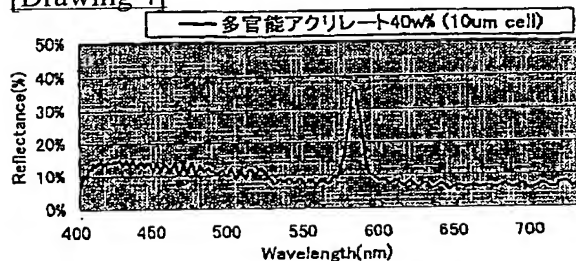


図3 干渉光の図(左:反射型 右:透過型)

[Drawing 4]



顕微分光で測定した反射スペクトル

図4 反射スペクトル

[Translation done.]